The Big Five IoT Challenges

If industry predictions are accurate, we're on the cusp of an Internet of Things (IoT) explosion: forecasts suggest tens of billions of components will soon be using the IoT to transmit data or receive operating instructions. These connected 'things' could be anything from basic sensors to complex machines, such as aircraft or cars. Power management of these devices are crucial. **Andrea Dodini, European Marketing Manager, Keysight Technologies, UK**

Many IoT components will need to be relatively simple and able to operate reliably and autonomously for long periods. But there's also a need for more complex components, such as data aggregation points and gateways between networks of connected devices and the wider world. But regardless of what their products will be used for, IoT designers face five common challenges.

Integrating an increasing number and variety of components

First - mixed-signal integrated circuit design has come a long way, and we can now make devices that are smaller, cheaper, more energy-efficient and better-performing than their discrete predecessors. The flip-side is that designs are more complex, with radio frequency (RF), analogue and digital functions all needing to be designed and housed on the same substrate. This complexity is a challenge worth tackling. Early evidence shows there's definite demand for these integrated components in the IoT world, a good example being low-powered microcontrollers with built-in wireless communication capability and interfaces to connect actuators and sensors.

The need for long battery life

Second - long battery life is essential if you're to minimize maintenance costs, particular when your designs feature large numbers of sensors. Lots of designers look to achieve the required energy-efficiency through low duty cycles and by implementing sleep and idle modes whenever possible.

Things become more complex in high-performance devices, where processors, displays and communications interfaces all require varying amounts of power. To achieve energy-efficiency here, designers must understand how the components or subsystems interact, and the impact this has on every element's power usage.

How much current does the device require in each operating mode, and how long will it spend in each? Can you accurately measure currents ranging from nanoamps to tenths of amps? Overall, advances in battery technology, circuit design, communication strategy and the ability to harvest energy locally are extending the operational lifespans of remote and unattended IoT kit. To take advantage of these developments and make the right software and hardware decisions, designers need to understand how each area will impact on the life expectancy and thermal requirements of their products. This will enable them to understand how the device will perform in real-world conditions.

The need for high power and signal integrity

Third - for any IoT device to operate reliably, signal integrity (SI) and power integrity (PI) must be high. This is particularly important in low-voltage or high-clock-frequency circuits, which are much less tolerant of crosstalk. The four key SI challenges are around a single net, the couplings where multiple nets meet, power distribution networks' power and ground paths, and electromagnetic interference (EMI). Designers can address these by minimising power delivery network impedance, shortening the return path lengths, controlling impedances through interconnects, reducing coupling by ensuring sufficient space between circuit traces, and through good shielding and grounding.

PI looks at how well source power is converted and transmitted to where it will be used. In the low-power devices many IoT designers are creating, DC supply voltages must be delivered within tolerances of just 1 %. These incredibly tight bands mean data and clock signals could be impacted by any transients, ripple or noise on the supply rails. The challenge

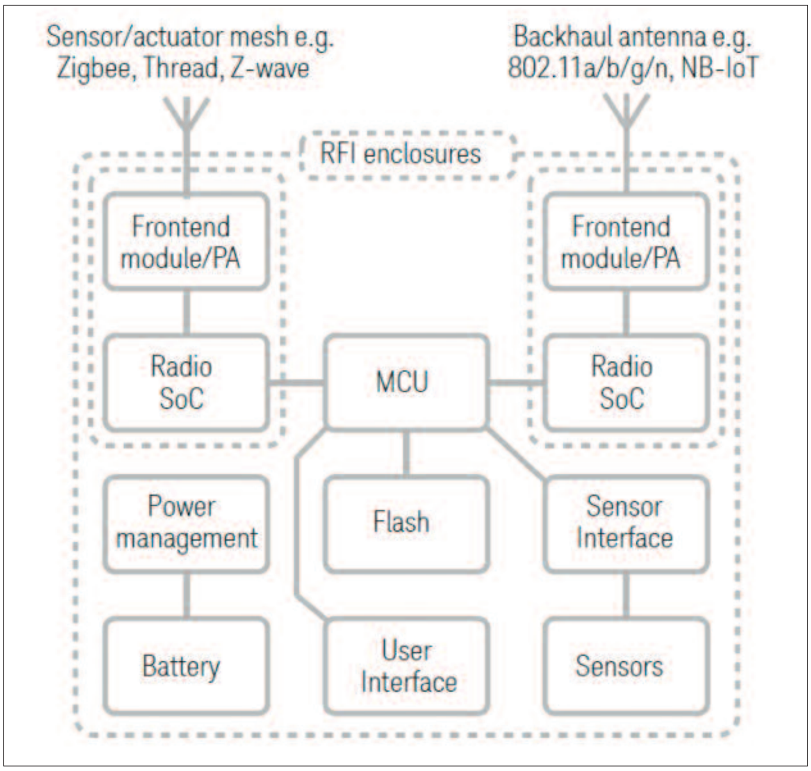

Figure 1: **Many Internet of Things devices will be made up of numerous components, each of which will require varying amounts of power**

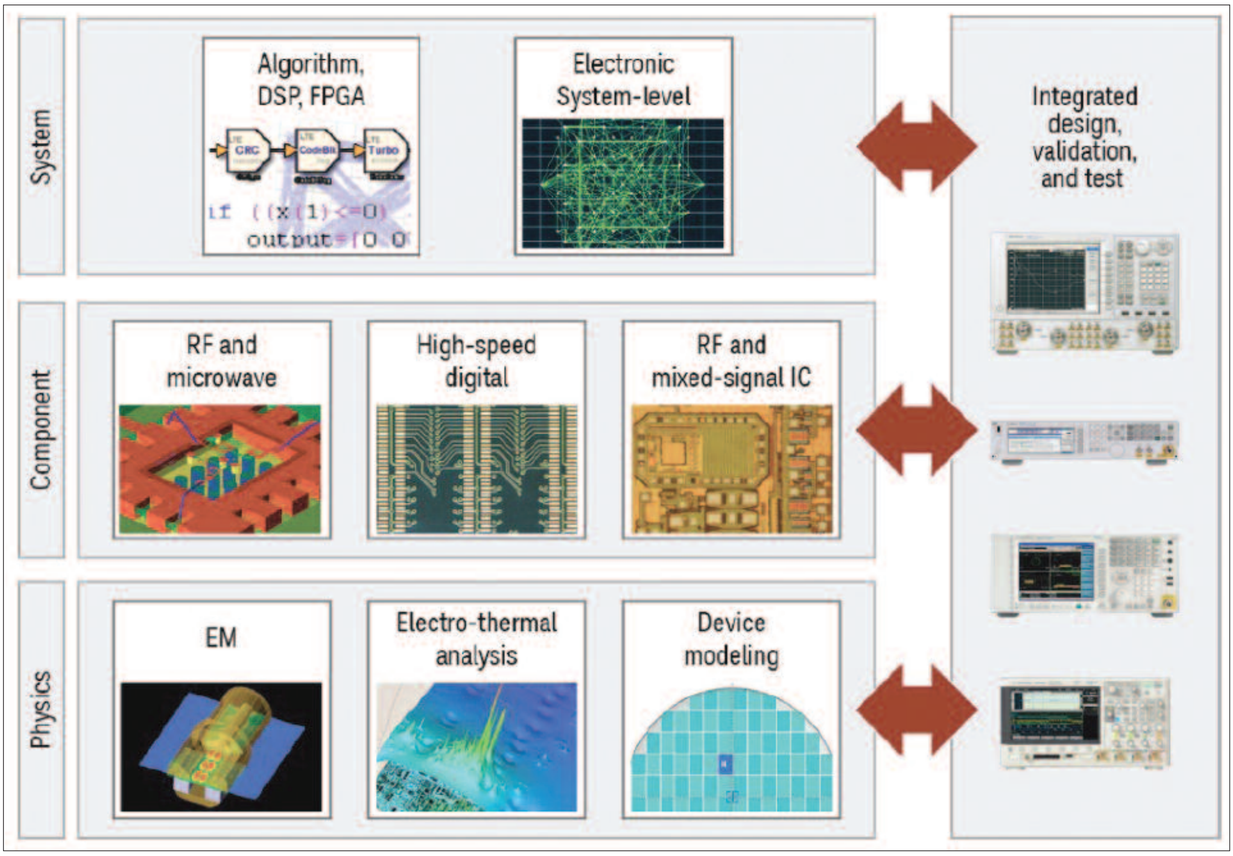

Figure 2: IoT designers can use Keysight's integrated tools to shape, validate and test their products

is to measure AC signals on these rails – as the signals continue to get faster and smaller.

Working with multiple communications standards

Forth- the huge range of use cases for IoT devices means lots of different wireless technologies and standards are emerging and being used. Where self-driving cars will need highly reliable, high-bandwidth connections, a sensor running off a small battery will likely use a short-range wireless connection with a low duty cycle. Other devices, such as smartphones, support multiple wireless standards (including Bluetooth, Wi-Fi, NFC and cellular).

Designing equipment that supports multiple standards makes measurement and testing increasingly complex, because each standard will have different test requirements. Designers need to ensure their components can work together effectively and adhere to more than one standard concurrently.

On top of the design challenges, testing compliance with multiple standards can be expensive if separate equipment is needed for each standard. This is why many are adopting flexible, multi-standard testing instruments that allow for the addition of new standards as these emerge.

Operating in increasingly crowded communications bands

Fifth- as the number of IoT devices expands, so communications resources are becoming more crowded, particularly the (unlicensed) ISM radio band. For

Figure 3: Many IoT devices draw different amounts of current at different times. SMUs enable designers to measure this in real time, thanks to seamless measurement ranging

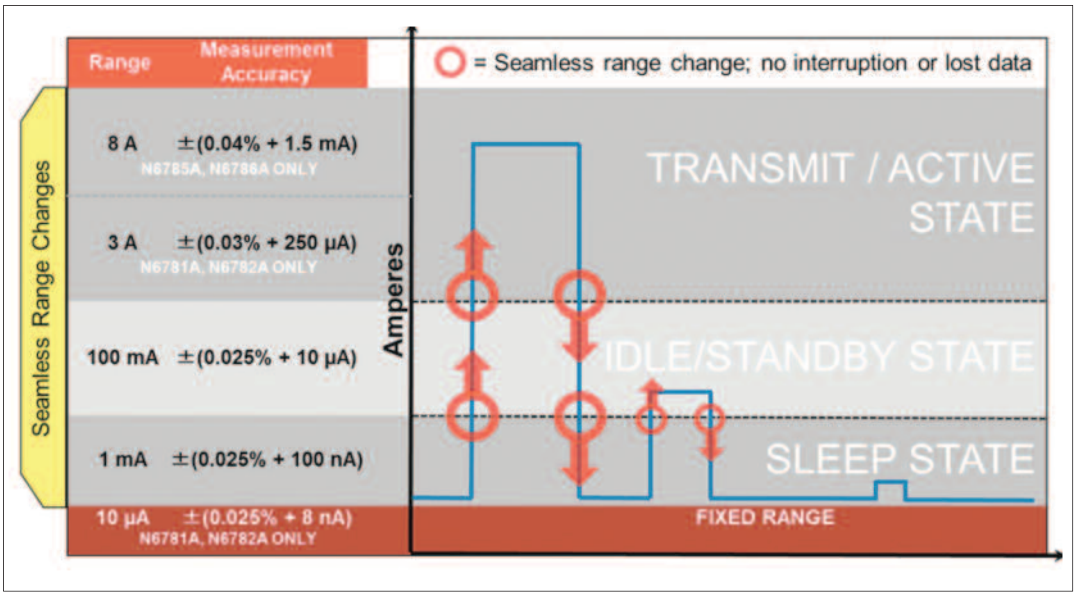

Figure 4: State-of-the-art testing hardware like the X-Series SA provides a consistent, full-lifecycle measurement framework for IoT devices

designers, this means ensuring their products will work effectively in busy signal bands, without causing co-channel or adjacent-channel interference. This is essential if the products are to comply with network and regulatory requirements. Moreover, given that many IoT devices will be operating simultaneously and in close proximity to other equipment, they'll need to undergo radiated and conducted emissions and immunity testing. The tools used to test the devices must therefore also comply with the relevant standards.

Thus many Internet of Things devices will be made up of numerous components, each of which will require varying amounts of power (Figure 1).

Solving the challenges

Keysight EEsof is a suite of electronic design automation (EDA) tools that use design flows to enable IoT developers to simulate the operation of their products at the physical, component and system level (Figure 2).

System architects and algorithm developers can use SystemVue to test different ways of implementing their wireless communication systems' physical layer. This electronic system-level design tool comes with virtual measurement utilities for predicting how the system will perform.

Advanced Design System, or ADS, is for co-designing boards, packages and integrated circuits. Designers can use it to simulate products at circuit and 3D electromagnetic levels, even when the circuits comprise multiple technologies. ADS comes with 3D planar and 3D electromagnetic field solvers, electro-thermal analysis and a real-time optimization cockpit. Furthermore, it provides access to libraries for the latest wireless communication standards. ADS also supports signal integrity analysis, through its S-parameter and AC simulators. These calculate how much noise each component in the circuit will make and how this will impact the rest of the network.

SIPro, another element of ADS, is for electromagnetic characterization of high-speed links on complex circuit boards. Meanwhile, PIPro enables analysis of DC dynamic voltage (IR) drop, power-plane resonance and alternating current (AC) impedance.

Then there are electromagnetic simulation tools, encompassing FDTD, Method of Moments and FEM. These enable designers to analyse potential parasitic effects and coupling in a range of complex 3D structures.

A final tool to mention is GoldenGate RFIC Simulation Software, for mixed-signal radio frequency integrated circuit design. It offers a full design flow for IoT kit, linking design and analysis at component, subsystem and system levels.

To analyse battery current-drain, designers can use Keysight's source measurement units (SMUs), the N6781A or N6786A (Figure 3). Both offer seamless measurement ranging, to measure the dynamic current drain seen in many battery-powered devices. Furthermore, the units are able to mimic real batteries, while zero-burden voltmeters and ammeters enable run-down testing.

For signal and power integrity, you'll need tools to validate simulation results such as the ENA Option TDR (for interconnect test), Infiniium oscilloscopes (for transmitter test) and Bit Error Radio Test solutions (for receiver test).

To test wireless devices, Keysight has a range of one-box, benchtop and modular testers. These can be used throughout product development to provide a consistent measurement framework for easy comparison of results.

The testing platforms work with Keysight's Signal Studio, X-Series (Figure 4) and 89600 VSA software. Signal Studio enables designers to create bespoke, standards-compliant waveforms. X-Series provides the ease of one-button testing for different types of wireless. And 89600 VSA is a powerful digital modulation analysis tool, ideal for deeper troubleshooting.

Conclusion

Anyone designing for the IoT will face a common set of challenges. These include maximising energy-efficiency to prolong devices' operating lives, dealing with interference and ensuring compliance with a range of standards. The key to overcoming these hurdles more easily is to take advantage of integrated design, simulation and measurement tools.